Review Article

Shoulder Arthroplasty: Prosthetic Options and Indications

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Abstract

Glenohumeral arthropathy and failed shoulder arthroplasty can lead to debilitating pain, reduced motion and strength, and limited function. Primary osteoarthritis, posttraumatic osteoarthritis, rheumatoid arthritis, cuff tear arthropathy, and osteonecrosis are common in this patient population. Shoulder arthroplasty may fail because of problems with the prosthesis, such as wear, loosening, and dislocation of the components, or because of bone and soft-tissue problems, such as glenoid arthrosis and rotator cuff tear. The disparate pathogenesis of these processes presents unique challenges to the treating surgeon and requires diagnosis-specific treatment options, whether involving hemiarthroplasty, total shoulder arthroplasty, or reverse total shoulder arthroplasty. Until recently, prosthesis options were limited to a stemmed humeral component with or without a polyethylene glenoid component. The array of prosthetic options currently available allows individualized treatment.

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Shoulder arthroplasty dates to 1893, when the French surgeon Jules-Émile Péan implanted a platinum-and-rubber prosthesis to replace a glenohumeral joint that had been destroyed by tuberculosis.[1] Little progress in design and functionality was made until 1951, when Neer developed an unconstrained Vitallium prosthesis for the treatment of severe proximal humerus fracture.[2,3] This device offered better pain relief and function than did the resection arthroplasty of that era. As the indications for shoulder arthroplasty were expanded, Neer sought to provide a shoulder prosthesis that would afford better pain relief for patients with arthritis. The success of total hip arthroplasty influenced Neer to develop the first modern total shoulder prosthesis, the Neer II (Smith & Nephew, Memphis, TN). Introduced in 1974, the prosthesis consisted of a redesigned humeral component and an all-polyethylene glenoid resurfacing component. Also popularized in the 1970s were fixed-fulcrum constrained reverse ball-and-socket shoulder prostheses, designed for patients with pain and limited function resulting from arthritis and concomitant rotator cuff deficiency.[3-5] These prostheses were rapidly abandoned because of design characteristics that led to early mechanical failure. More than 70 different shoulder systems have been developed since Neer's initial design.

Indications for shoulder arthroplasty now include not only severe proximal humerus fractures but also primary osteoarthritis (OA), posttraumatic arthritis, cuff tear arthropathy, inflammatory arthritis, shoulder girdle tumors, osteonecrosis, pseudoparesis caused by severe rotator cuff deficiency, and failed shoulder arthroplasty. Even so, prosthesis options for the shoulder have largely been limited to a minimally constrained, stemmed, Neer-type humeral component with or without a cemented polyethylene glenoid component. Knowledge of the array of shoulder prostheses currently available and the indications for each, as well as the use of treatment algorithms, can lead to optimized patient outcomes.

Shoulder Prosthesis Options

Hemiarthroplasty, total shoulder arthroplasty (TSA), and reverse total shoulder arthroplasty (RTSA) are the three main types of shoulder reconstruction that require prosthetic components. In hemiarthroplasty, the humeral articular surface is replaced with a stemmed humeral component coupled with either a standard humeral head or an extended-coverage head (ie, CTA reverse shoulder prosthesis, DePuy, Warsaw, IN [CTA]), or with a resurfacing humeral component. Minimally constrained anatomic TSA involves replacement of the humeral articular surface with either a stemmed humeral component or a resurfacing humeral component as well as replacement of the glenoid articular surface with either a polyethylene glenoid component (metal-backed or not) or biologic material (eg, autograft or allograft soft tissue). Semiconstrained RTSA involves replacement of the humeral articular surface with a stemmed humeral component containing a polyethylene humerosocket and replacement of the glenoid with a highly polished metal ball known as a glenosphere.

Hemiarthroplasty

Shoulder hemiarthroplasty that involves a stemmed humeral component with a standard humeral head was developed more than 50 years ago for the treatment of proximal humerus fractures.[2,3] Current indications for hemiarthroplasty include severe proximal humerus fracture, primary arthritis, arthritic conditions in which the glenoid bone stock is inadequate to support a glenoid prosthesis, cuff tear arthropathy, and early-stage osteonecrosis without glenoid involvement.

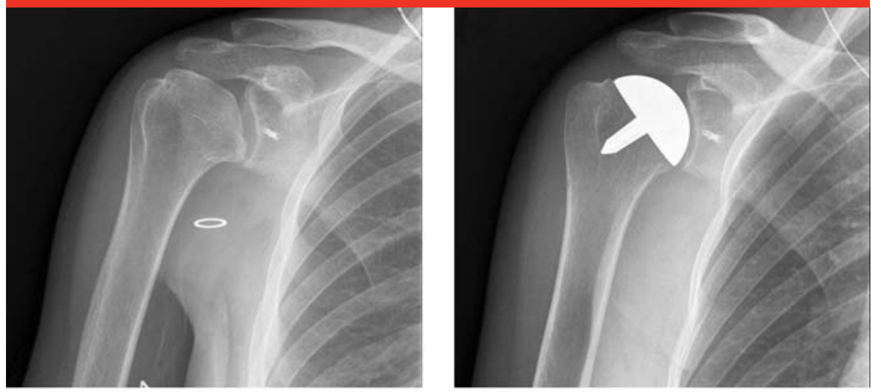
The effectiveness of hemiarthroplasty as a treatment for unreconstructible proximal humerus fracture is well documented. Moeckel et al[6] used a modular prosthesis in 22 patients with three-part, four-part, or head-splitting proximal humerus fracture. All but two patients had satisfactory pain relief, and those two improved after revision surgery. Overall scores were inversely correlated with patient age and with time from injury to operation. Robinson et al[7] evaluated 138 patients treated with primary hemiarthroplasty for proximal humerus fracture and fracture-dislocation. The overall median modified Constant score was 64 at 1-year follow-up. Poorer results were associated with advancing age, neurologic deficit, postoperative complications requiring revision, and an eccentrically located prosthesis with retracted tuberosities.

Controversy exists regarding whether hemiarthroplasty or TSA is superior for the management of glenohumeral OA. Edwards et al[8] compared the two techniques in a large multicenter series. Several parameters were significantly better for TSA at an average 43-month follow-up: active forward elevation ($P < 0.0005$), active external rotation ($P < 0.015$), Constant score ($P < 0.0005$), incidence of radiolucent lines around the humeral component ($P < 0.001$), and humeral implant migration ($P < 0.033$). These findings seem to indicate that TSA is more effective than hemiarthroplasty in patients with primary OA. In contrast, Lo et al[9] found no significant difference in quality-of-life measures between hemiarthroplasty and TSA in a prospective, randomized study with minimum 2-year follow-up. However, there was a trend toward superior results in the TSA group. Radnay et al[10] performed the largest meta-analysis to date comparing hemiarthroplasty with TSA for the treatment of primary glenohumeral OA. These authors identified 23 studies published between 1966 and 2004, with a total of 1,952 patients and mean follow-up of 43.4 months. When outcomes assessment data were pooled across studies and statistical analysis was performed, the authors found significantly greater pain relief ($P < 0.0001$), forward elevation ($P < 0.0001$), gain in forward elevation ($P < 0.0001$), gain in external rotation ($P = 0.0002$), and patient satisfaction ($P < 0.0001$) with TSA compared with hemiarthroplasty. In addition, the rate of revision surgery was significantly lower with TSA than with hemiarthroplasty (6.5% versus 10.2%; $P < 0.025$). However, interpretation of these results must be tempered by an awareness that all but three of the included studies were retrospective, observational case series.

Advanced glenoid arthrosis and wear has been shown to negatively affect the results of hemiarthroplasty for OA.[11-13] Levine et al[11] reviewed 31 shoulders managed with hemiarthroplasty for glenohumeral OA. Satisfactory short-term outcomes correlated most significantly with the presence of posterior glenoid wear. A satisfactory result was reported in 86% of patients with a concentric glenoid and in 63% of patients with a nonconcentric glenoid. Rispoli et al[12] reported the results of 51 patients who were treated with hemiarthroplasty for OA. At long-term follow-up (average, 11.3 years), 10 patients had excellent results, 20 had satisfactory results, and 21 had unsatisfactory results. At final follow-up, 16 patients had moderate to severe pain, and 9 patients required conversion to TSA for glenoid arthrosis. Wirth et al[13] reported satisfactory overall results at a minimum 5-year follow-up in patients treated with hemiarthroplasty for OA. However, the authors preferred TSA for patients with more advanced glenoid arthrosis.

In 1983, Neer coined the term "cuff tear arthropathy" to describe severe rotator cuff tearing and end-stage arthritic disease.[14] He recognized that the bone and soft-tissue deficiency inherent in patients with this condition presented significant difficulties for surgical reconstruction. In the patient with cuff tear arthropathy, TSA can be complicated by glenoid loosening or, in the patient with inadequate glenoid bone stock, may be impossible to perform. These glenoid complications can be avoided with hemiarthroplasty, which has been reported to provide reasonable results in the treatment of glenohumeral arthritis and severe rotator cuff deficiency. Sanchez-Sotelo et al[15] reviewed the results of 33 shoulders treated with hemiarthroplasty for arthritis in conjunction with rotator cuff deficiency. A successful result was achieved in 67% of shoulders, with an improvement in mean active elevation from 72° preoperatively to 91° postoperatively ($P = 0.008$). Williams and Rockwood[16] reported satisfactory results in 18 of 20 patients with glenohumeral arthritis and rotator cuff deficiency. Flexion increased from 70° preoperatively to 120° postoperatively. However, five patients achieved <90° of active flexion. These results are clearly inferior to those in patients with an intact rotator cuff; however, hemiarthroplasty offers better outcomes than do resection arthroplasty, arthrodesis, and benign neglect.

Figure 1



A, B

A, Preoperative AP radiograph of the humeral head in a 21-year-old woman who had been a competitive swimmer. Following two failed stabilization procedures, the patient rapidly developed arthrosis as a result of migration of metallic suture anchors into an intra-articular position. **B,** Postoperative AP radiograph following resurfacing humeral hemiarthroplasty.

Osteonecrosis of the humeral head commonly occurs as the result of severe proximal humeral fracture. However, it also may be caused by corticosteroid use, radiation therapy, alcohol abuse, endocrine disorders, sickle cell disease, and caisson disease.[17] Advanced cases are characterized by collapse of the humeral articular surface and painful arthritic changes, which can lead to degeneration of the glenoid articular surface. Hemiarthroplasty is an effective treatment when the humeral head is involved but the glenoid is preserved. Hattrup and Cofield[17] reviewed a series of 71 hemiarthroplasties performed for osteonecrosis of the humeral head. Following surgical treatment, 80.7% of patients were better or much better and 75.1% had from no pain to occasional moderate pain. The authors reported a mean active flexion of 126°, mean active external rotation of 57°, and mean American Shoulder and Elbow Surgeons (ASES) score of 69. Better results were seen in steroid-induced osteonecrosis than in posttraumatic osteonecrosis. When the glenoid was involved, the authors performed TSA.

Resurfacing Hemiarthroplasty

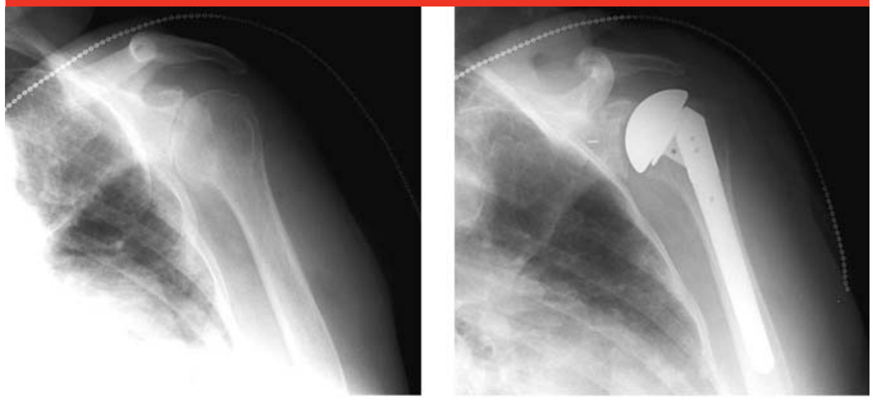
Resurfacing humeral hemiarthroplasty alone has been shown to be effective for managing a variety of arthritic conditions of the shoulder.[18,19] Preservation of the humeral head allows the surgeon to maintain the native head-shaft angle, offset, inclination, and version. This technique also may facilitate later conversion to a conventional TSA. Resurfacing humeral hemiarthroplasty is an attractive option for the young, active, or athletic patient in whom loosening or wear of a polyethylene glenoid component is a concern (Figure 1).

In a recent series, 36 active patients younger than 55 years were treated with resurfacing arthroplasty.[19] Glenoid resurfacing was done in only four patients, who underwent biologic resurfacing with either dermal or meniscal allograft. At a mean follow-up of 38.1 months, the visual analog pain score decreased from 7.5 to 1.3 ($P < 0.001$), the ASES score improved from 29.8 to 87.7 ($P < 0.001$), and the Single Assessment

Figure 2

Postoperative AP radiograph of the right shoulder in a 79-year-old man with cuff tear arthropathy who was treated with humeral hemiarthroplasty using a CTA head.

Figure 3



A **B**

A, Preoperative AP radiograph of the left shoulder in a 65-year-old woman with primary glenohumeral osteoarthritis. **B,** Postoperative anteroposterior radiograph taken after minimally constrained anatomic total shoulder arthroplasty with a stemmed humeral component and a polyethylene glenoid component.

Numeric Evaluation score improved from 24.7 to 90.4 ($P < 0.001$). All patients but one were satisfied with their results and returned to their desired level of activity. The authors attributed the good results to correction of posterior glenoid wear and humeral subluxation to a concentrically reduced humeral prosthesis centered on the glenoid. To achieve this result, the authors performed aggressive anterior and inferior soft-tissue releases and contouring of the arthritic glenoid. The authors acknowledged that late glenoid arthrosis requiring revision to TSA remains a concern in this young patient population.[19]

Hemiarthroplasty With an Extended-coverage Head

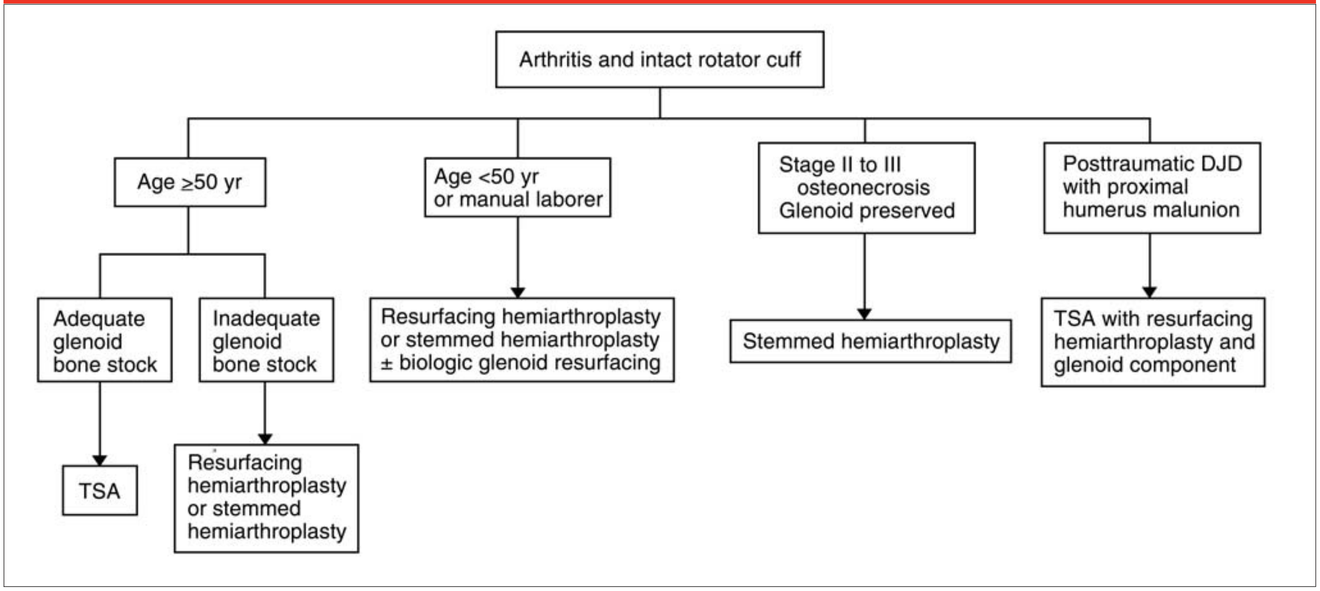
In the patient with cuff tear arthropathy, the rotator cuff can no longer maintain the humeral head in a centered position. This leads to proximal migration of the humerus, with eventual articulation of the humerus and acromion. Femoralization of the humeral head (ie, rounding of the tuberosities) and acetabularization (ie, concave erosive change of the undersurface) of the glenoid and acromion[14] may lead to continued bone-on-bone contact between the greater tuberosity and the acromion, with pain developing despite implantation of a standard humeral head prosthesis. This outcome led to the development of the CTA head, which has an extended humeral articular surface.[20,21] The increased surface area for articulation results in decreased greater tuberosity impingement against the acromion (Figure 2).

In a series of 60 shoulders with cuff tear arthropathy managed with the Global Advantage CTA head (DePuy), forward flexion improved from 56° preoperatively to 116° postoperatively, pain decreased from 9.3 to 1.9 on the visual analog pain scale, and the average ASES score increased from 29 to 79.[21] Hemiarthroplasty with a CTA head may be considered for the patient whose humeral head is contained by the coracoacromial arch. However, hemiarthroplasty is unlikely to restore motion and function in the patient with a decentered humeral head and frank anterosuperior instability. RTSA should be considered for such a patient.

Total Shoulder Arthroplasty

Minimally constrained anatomic TSA most commonly involves implantation of a stemmed humeral component and a polyethylene glenoid component. The primary indication for TSA is a painful shoulder caused by glenohumeral OA that is not successfully managed nonsurgically, in conjunction with loss of articular cartilage, incongruent osseous surfaces, and an intact rotator cuff. Radiographic changes include joint space narrowing, marginal osteophyte formation, subchondral sclerosis, and cysts (Figure 3). Other indications for TSA include inflammatory arthritis, advanced osteonecrosis with glenoid involvement, and posttraumatic degenerative joint disease with proximal humerus malunion (Figure 4). Rodosky and

Figure 4



Treatment algorithm delineating arthroplasty options for the patient with shoulder arthritis and an intact rotator cuff. DJD = degenerative joint disease, TSA = total shoulder arthroplasty

Bigliani[22] reported the current indications for TSA: pain caused by glenoid incongruity that is unresponsive to nonsurgical treatment in patients with adequate glenoid bone stock, good surgical risk and motivation, and absence of active infection, paralysis, or destruction of the rotator cuff and deltoid muscles.

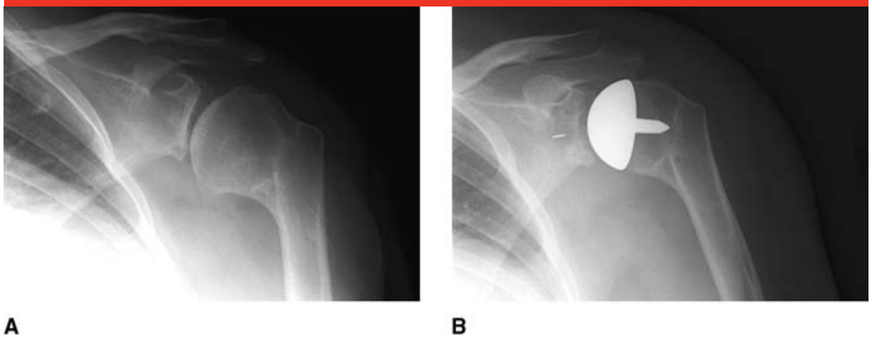
Numerous authors have documented the efficacy of conventional TSA.[3,17,23-28] In 1982, Neer et al[3] presented the outcomes of 194 shoulders managed with a minimally constrained TSA at a minimum 2-year follow-up. All but four patients stated that they had benefited from the procedure. In 1984, Cofield[23] reviewed 73 TSAs implanted with the Neer prosthesis at 2- to 6.5-year follow-up. Active abduction improved 44°, to an average of 120°. In the absence of postoperative complications, the results were predictably good. In a follow-up study, Torchia et al[28] reviewed 89 TSAs at a minimum follow-up of 5 years. Range of motion improved an average of 40°, and 67 patients had mild or no pain postoperatively. The probability of prosthesis survival was 93% at 10-year follow-up and 87% after 15 years.

Compared with hemiarthroplasty, TSA with glenoid resurfacing results in less pain, a better fulcrum for active motion, and better strength. In a prospective, randomized, controlled trial analyzing the effect of glenoid resurfacing in patients with OA who were scheduled for shoulder arthroplasty, Gartsman et al[24] reported superior pain relief and internal rotation with TSA versus hemiarthroplasty at a mean follow-up of 35 months. Three patients who were treated with hemiarthroplasty required conversion to TSA. Orfaly et al[27] analyzed functional outcomes after TSA versus hemiarthroplasty for OA and reported modest superiority in functional outcome with TSA in the medium term (range, 2 to 8 years). Despite inconsistent outcomes reporting and a preponderance of poor study design in the current literature, the meta-analysis by Radnay et al[10] showed better pain relief, range of motion, and patient satisfaction with TSA than with humeral head replacement in patients with glenohumeral OA.

TSA is also indicated for inflammatory arthritis.[25,29] In the individual with inflammatory arthritis, the glenoid is often eroded centrally rather than posteriorly (as in OA). Radiographic changes that are evident with rheumatoid arthritis include osteopenia, periarticular erosion, and medialization of the joint line. Cement fixation of the humeral component frequently is required because of cortical thinning, softening of the cancellous bone, and marginal erosions at the humeral head. Medial wear of the glenoid surface may result in a decrease in glenoid bone stock, which may require bone grafting to ensure adequate support of the glenoid component.

In 2004, Collins et al[29] prospectively compared hemiarthroplasty with TSA for the treatment of inflammatory arthritis. At a minimum follow-up of 24 months, active forward elevation was better in the TSA

Figure 5



A, Preoperative AP radiograph of the left shoulder in a 58-year-old woman with posttraumatic arthritis and severe varus malunion. **B**, Postoperative AP radiograph after total shoulder arthroplasty with a resurfacing humeral component and a polyethylene glenoid component.

group. However, more patients in the hemiarthroplasty group had worse arthritis or irreparable rotator cuff tears preoperatively, which may have partially accounted for their decreased motion compared with patients treated with TSA. The authors recommended glenoid resurfacing in the patient with inflammatory arthritis in the presence of an intact or reparable rotator cuff and adequate bone stock. Kelly et al[25] reported excellent pain relief with TSA for the management of rheumatoid arthritis and found that rotator cuff tearing was associated with smaller gains in postoperative flexion.

Resurfacing Total Shoulder Arthroplasty

Prosthesis resurfacing has become an increasingly popular method of managing shoulder pathology. Humeral surface replacement arthroplasty is designed to replace the damaged joint surface and restore normal anatomy with minimal bone resection. This technique offers several advantages over implantation of a stemmed humeral component, including bone preservation and less complicated instrumentation. Additionally, there is no need for a straight humeral canal to accommodate a long stem. One disadvantage of a resurfacing prosthesis is that glenoid exposure can be more difficult because the humeral head is not resected.

Levy and Copeland[18] evaluated 79 shoulders (42 TSAs, 37 hemiarthroplasties) that were managed with Copeland cementless surface replacement arthroplasties and found the results to be comparable to those with stemmed prostheses. Constant scores improved from 33.8% preoperatively to 94.0% postoperatively in the TSA group and from 40% to 91% in the hemiarthroplasty group. Levy and Copeland[18] believe that the indications for surface replacement arthroplasty are essentially the same as for a conventional stemmed prosthesis and that the latter is required only in the patient with severe bone loss in conjunction with articular surface collapse, acute fracture, and fracture nonunion.

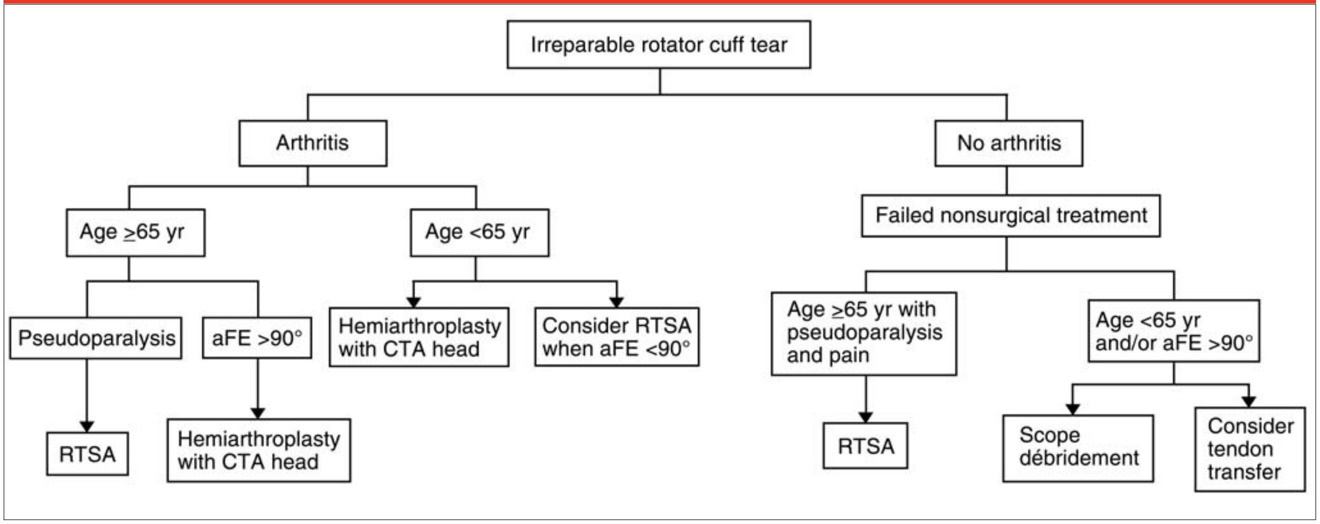
Proximal humerus malunion is particularly challenging to manage.[30,31] The absence of a stem makes a resurfacing prosthesis ideally suited for the patient with posttraumatic arthritis and humeral deformity who would otherwise require a humeral osteotomy to accommodate the stemmed implant (Figure 5).

Total Shoulder Arthroplasty With Biologic Glenoid Resurfacing

The young patient with disabling arthritis and the manual laborer whose job requires heavy lifting or overhead work present unique treatment challenges. Accelerated loosening and wear of the polyethylene glenoid component are concerns in these patient populations. Traditionally, such patients were treated with glenohumeral fusion rather than TSA. Pain relief can be achieved with shoulder fusion, but this technique results in severely limited motion and is often not a preferred option. TSA consisting of biologic glenoid resurfacing, in conjunction with a cementless porous-coated humeral prosthesis, was developed to address these concerns.

In an early study on the use of this technique, Burkhead and Hutton[32] performed biologic glenoid resurfacing on 14 patients, 6 of whom were available for 2-year follow-up. The glenoid was resurfaced using a layer of anterior capsule in three patients and autogenous fascia lata in three patients. Five patients had an excellent result, and one had a satisfactory result. All six patients reported pain relief. The authors reported postoperative average elevation of 138° and external rotation of 50° as well as internal rotation to the T12 spinous process. In 2007, investigators from the same institution evaluated 34 shoulders at 2- to 15-year follow-up.[33] Achilles tendon allograft was used in 18 shoulders, autogenous fascia lata in 11, and anterior capsule in 7. Eighteen patients had an excellent result, 13 had a satisfactory result, and 5 had an unsatisfactory result according to the Neer criteria. Unsatisfactory results were associated with infection and with using capsular tissue as the resurfacing material. The authors believed

Figure 6



Treatment algorithm for irreparable rotator cuff tear. aFE = active forward elevation, RTSA = reverse total shoulder arthroplasty

that the overall results were comparable to those with conventional TSA. Because of its better load-bearing properties, meniscal allograft has also been described as a resurfacing material.[34,35]

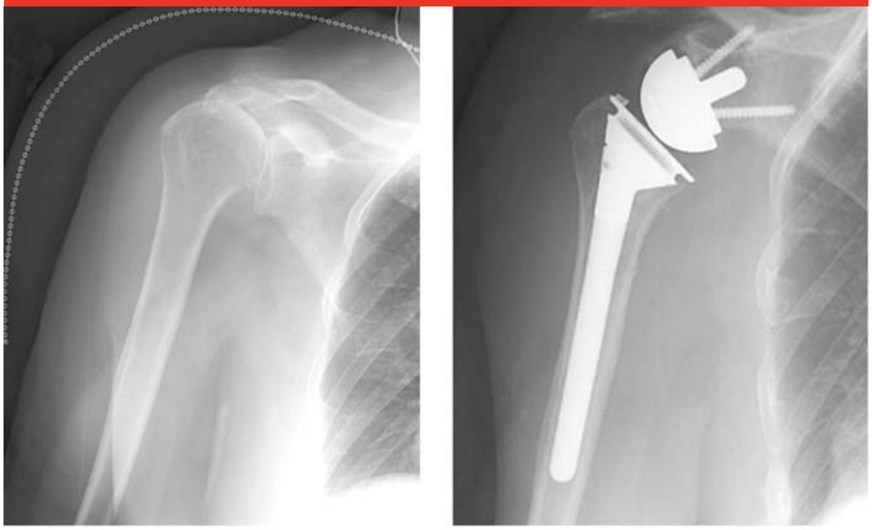
Reverse Total Shoulder Arthroplasty

Minimally constrained anatomic TSA provides reliable pain relief and improved function in most arthritic shoulders with an intact or reparable rotator cuff. However, results of TSA are less satisfactory in patients with glenohumeral arthritis combined with severe rotator cuff deficiency and in patients with a failed arthroplasty in whom the rotator cuff is deficient or scarred, or has undergone fatty infiltration (Figure 6). In these situations, the normal kinematics are altered, and the humerus tends to migrate superiorly because the deltoid contraction is relatively unopposed. Loss of the glenohumeral fulcrum and deltoid mechanical disadvantage can lead to pseudoparesis (ie, active forward elevation <90°).[5] The individual with such compromised function may be unable to lift the arm away from the side, let alone over the head.

Constrained fixed-fulcrum reverse ball-and-socket prostheses that were developed in the 1970s to compensate for rotator cuff deficiency were quickly abandoned because of high early mechanical failure rates. It has been theorized that these early designs lateralized the center of rotation, creating a long lever arm in the glenoid prosthesis. The resultant forces on the glenoid fixation led to early prosthetic loosening and failure. Efforts to address these shortcomings led to the development of the modern Grammont reverse prosthesis (ie, Delta III, DePuy), which has a medialized center of rotation.[4,36] This construct results in decreased forces on the glenoid fixation and, consequently, increased implant survivorship (Figure 7).

Boileau et al[36] reviewed 45 patients who were treated with the Grammont reverse prosthesis for cuff tear arthropathy, fracture sequelae, or revision arthroplasty. Overall, the three groups had an increase in elevation from 55° preoperatively to 121° postoperatively and an increase in Constant score from 17 to 58 points. Seventy-eight percent of the patients were satisfied with their result, and 67% had no or slight pain. Frankle et al[4] evaluated 60 patients treated with RTSA for glenohumeral arthritis and rotator cuff deficiency. The ASES score improved from 34.2 preoperatively to 68.2 postoperatively, and active forward elevation improved from 55.0° to 105.1°. Forty-one patients rated their result as good or excellent, 16 as satisfactory, and 3 as unsatisfactory. In 2005, Werner et al[5] reviewed a series of 58 patients treated with RTSA for pseudoparesis resulting from rotator cuff deficiency. Seventeen patients were treated with primary arthroplasty and 41 with revision surgery. At an average follow-up of 38 months, the relative Constant score improved from 29% to 64% (P < 0.0001), and active forward elevation improved from 42° to 100° (P < 0.0001). In each series, the complication rate following RTSA was higher than that reported after minimally

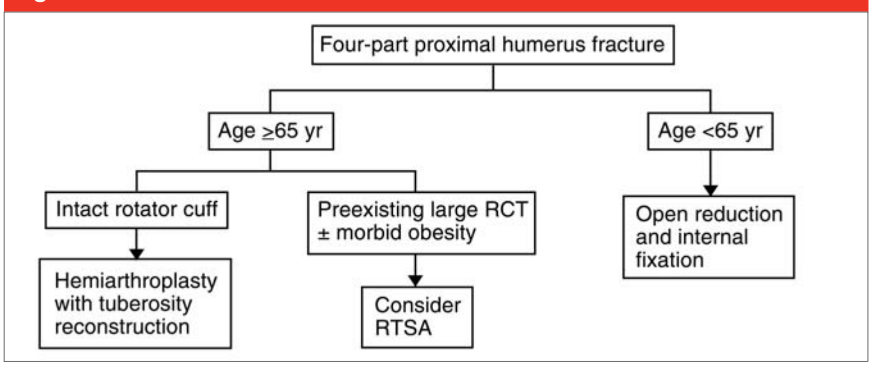
Figure 7



A **B**

A, Preoperative AP radiograph of the right shoulder in a 73-year-old woman with cuff tear arthropathy and painful pseudoparalysis. **B,** Postoperative AP radiograph following reverse total shoulder arthroplasty.

Figure 8



Treatment algorithm for four-part proximal humerus fracture. RCT = rotator cuff tear, RTSA = reverse total shoulder arthroplasty

constrained TSA.

Treatment of complex fractures of the proximal humerus in elderly patients can be challenging. Results of osteosynthesis may be compromised by osteonecrosis, loss of fixation, and hardware problems, whereas results following hemiarthroplasty may be compromised by displacement or resorption of the tuberosities and consequent rotator cuff dysfunction. Hemiarthroplasty provides reliable pain relief but inconsistent return of function. These inconsistent results have prompted some investigators to advocate primary RTSA for acute three- and four-part fractures in the elderly (Figure 8). Bufquin et al[37] evaluated a series of 43 patients with a mean age of 78 years who were treated with RTSA for acute proximal humerus fracture. Clinical outcomes were satisfactory, with a mean anterior elevation of 97° and a modified Constant score of 66%. Compared with conventional hemiarthroplasty, satisfactory mobility was obtained with RTSA despite tuberosity migration.

Revision Arthroplasty

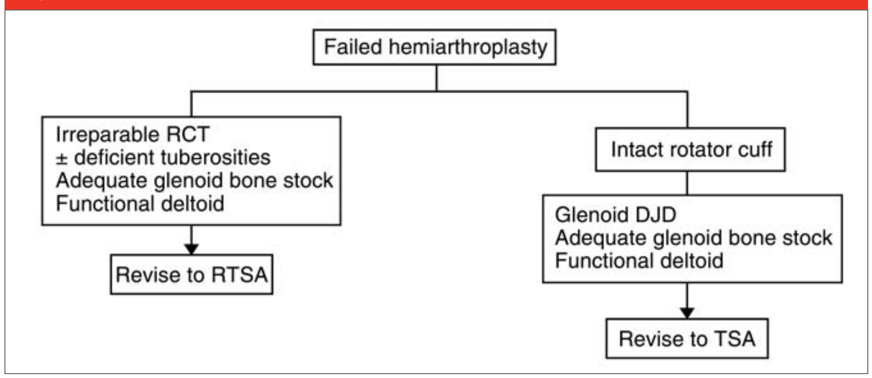
The number of shoulder arthroplasties performed has increased significantly in the past decade, creating an increased need for revision surgery (Figures 9 and 10). The main reasons for failure of shoulder arthroplasty can be classified as soft-tissue deficiency, osseous concerns (eg, glenoid arthrosis, bone loss), and implant problems (eg, malposition, improper sizing, wear, loosening). In the first report on this subject, Neer and Kirby[38] recognized that failure is often multifactorial and that soft-tissue scarring makes revision more difficult. In addition, these authors found that results with revision arthroplasty are inferior to those with primary arthroplasty and that individualized treatment is required for failed arthroplasty. Dines et al[39] analyzed the outcomes following revision TSA in 78 shoulders (75 patients). The shoulders were divided into two categories: those with osseous or component-related problems, and those with soft-tissue deficiency. Overall, 39 patients had a fair or poor result (52%). Revisions involving soft-tissue reconstruction yielded poorer results overall.

Glenoid arthrosis is the most common cause of failure after hemiarthroplasty. In fact, revision to TSA because of pain following hemiarthroplasty is more common than revision because of polyethylene glenoid component loosening (8.1% versus 1.7%, respectively).[10] Sperling and Cofield[40] reviewed 18 shoulders with painful glenoid arthritis that were converted to TSA from hemiarthroplasty. Although most patients experienced marked pain relief and improved motion, 7 of 18 patients had an unsatisfactory result; they either experienced limited range of motion or required reoperation. Carroll et al[41] identified 16 patients who underwent revision TSA for failed hemiarthroplasty with glenoid arthrosis. Evidence of posterior glenoid erosion was found in 64% of patients. Based on the 47% unsatisfactory rate and the complexity of the revision procedure, the authors concluded that results are better with primary TSA than with revision from hemiarthroplasty to TSA.

Glenoid component loosening is the most common cause of failure following TSA. When adequate glenoid bone stock remains after resection of the loose component, a new glenoid component may be implanted. There are no published guidelines on what amount of bone is adequate for reimplantation; thus, treatment must be tailored to each patient. Phipatanakul and Norris[42] reported on 24 patients who were converted from TSA to hemiarthroplasty with glenoid bone grafting to repair glenoid component loosening caused by osteolysis. Significant pain relief was reported following the revision procedure. Although graft subsidence occurred in 50% of cases (10 of 20), 92% of patients had satisfactory pain relief. Four patients underwent successful staged reimplantation of a glenoid component after graft consolidation.

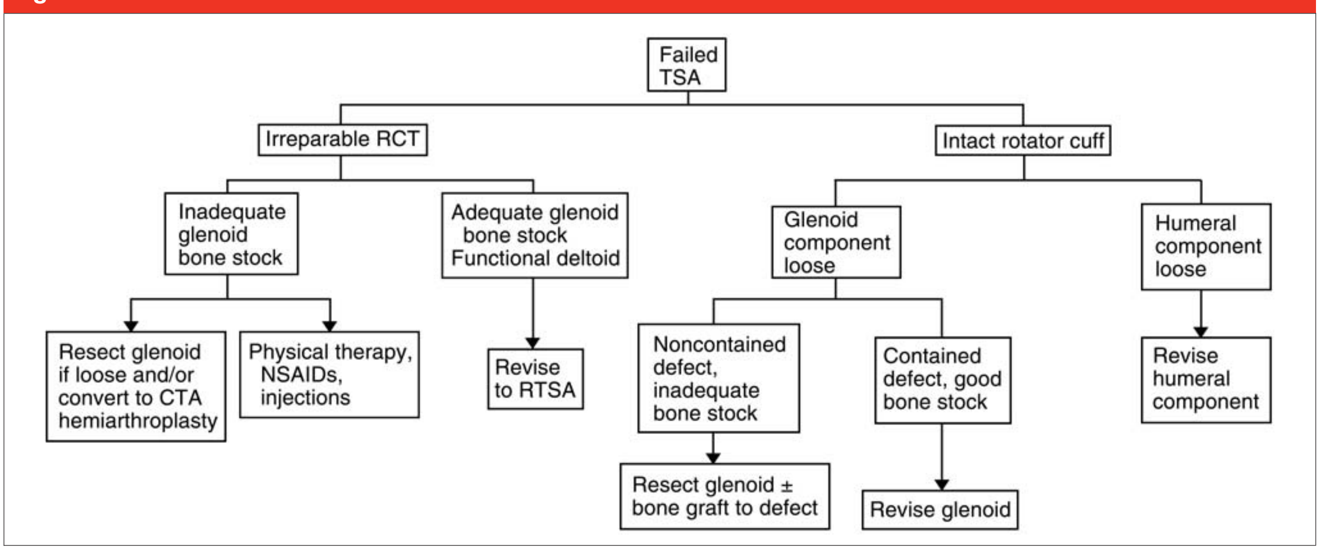
RTSA has recently become a valuable option in the patient with failed shoulder arthroplasty. Cases that were once deemed unreconstructible may now be salvaged with a reverse prosthesis (Figure 11). Sufficient glenoid bone stock to support the base plate and screws as well as a functional deltoid are required for successful revision to RTSA. Levy et al[43] reviewed 29 patients treated with RTSA for failed hemiarthroplasty after proximal humeral fracture. Many of these patients had significant proximal humeral bone loss and were treated with a proximal humeral allograft–prosthetic composite. The ASES score improved from 22.3 to 52.1, and forward elevation increased from 38.1° to 72.7°. There were 16 good or excellent results, 7

Figure 9



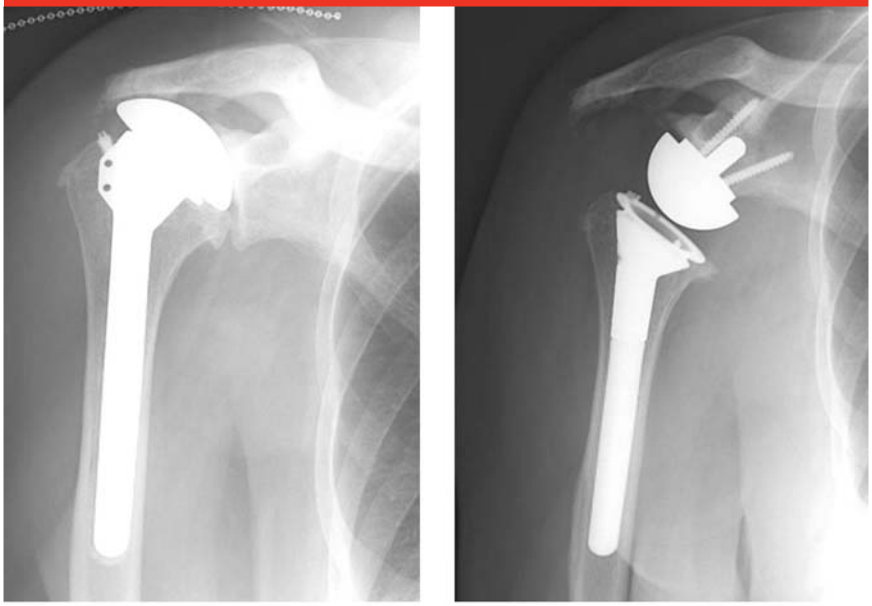
Treatment algorithm for failed hemiarthroplasty. DJD = degenerative joint disease, RCT = rotator cuff tear, RTSA = reverse total shoulder arthroplasty, TSA = total shoulder arthroplasty

Figure 10



Treatment algorithm for failed total shoulder arthroplasty (TSA). NSAIDs = nonsteroidal anti-inflammatory drugs, RCT = rotator cuff tear, RTSA = reverse total shoulder arthroplasty

Figure 11



A **B**

A, Preoperative AP radiograph of the right shoulder in a 70-year-old man with a history of several failed previous rotator cuff repairs. Standard humeral hemiarthroplasty failed to relieve pain and was complicated by anterosuperior escape of the humeral head with attempted elevation. **B,** Postoperative AP radiograph following successful revision to reverse total shoulder arthroplasty.

satisfactory results, and 6 unsatisfactory results, with a complication rate of 28%.

Summary

The variety of shoulder disorders and the many prosthetic options available can complicate treatment selection for the patient who requires shoulder arthroplasty. Patients with primary arthritis have reproducibly good results with shoulder arthroplasty, but multiple factors must be considered in the selection of the prosthesis, including patient age, activity level, bone stock, and rotator cuff status. Comparison of published studies on hemiarthroplasty and TSA suggests that TSA for primary OA generally provides superior results in terms of pain relief, function, strength, and patient satisfaction, along with a lower rate of revision surgery. Shoulders with posttraumatic arthritis or failed arthroplasty often have pathology that requires difficult surgical management. Complicating factors include muscle contracture, nerve injury, scarring, capsular and rotator cuff deficiency, deltoid problems, malunion, nonunion, and bone loss. RTSA is a powerful new tool in the treatment of patients with previously unreconstructible shoulder problems and/or failed arthroplasty.

The treatment algorithms presented offer guidelines for navigating the array of shoulder arthroplasty options available and the indications for each. They are not intended to imply that a level of evidence exists supporting the superiority of one type of prosthesis over another in a given situation. Indeed, in some instances, more than one type of prosthesis may be appropriate. Shoulder reconstruction can be exceedingly complex, and it must be emphasized that these algorithms cannot account for every possible situation. The surgeon must rely on his or her clinical acumen and experience to make treatment decisions that are tailored to the individual patient.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. Level I studies below include references 9, 10, and 24. Level II studies include references 7, 8, 26, 27, 29, and 36. References 17, 18, and 39 are level III studies. Level IV studies include references 2-6, 11-16, 19, 21, 23, 25, 28, 30-33, 37, 38, and 40-43. Level V studies include references 20 and 22.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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